10-1922

Bulletin No. 178 - The Irrigation of Barley

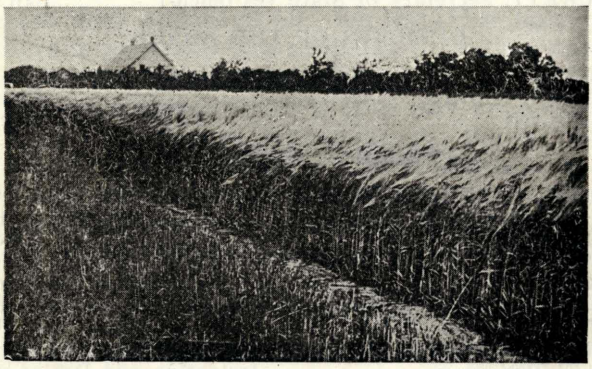
F. S. Harris

D. W. Pittman

THE IRRIGATION OF BARLEY

By

F. S. HARRIS and D. W. PITTMAN



BULLETIN NO. 178

Utah Agricultural College

EXPERIMENT STATION

Logan, Utah October, 1922

UTAH AGRICULTURAL EXPERIMENT STATION

BOARD OF TRUSTEES

A. W. IVINS.....Salt Lake City
ANGUS T. WRIGHT.....Ogden
C. P. CARDON.....Logan
LOIS C. HAYBALL.....Logan
FRANK B. STEPHENS.....Salt Lake City
JOHN D. PETERS.....Brigham City
W. S. HANSEN.....Fielding
R. L. JUDD.....Salt Lake City
J. H. WATERS.....Salt Lake City
E. O. HOWARD.....Salt Lake City
O. H. BUDGE.....Logan
H. E. CROCKETT, Secretary of State (ex-officio).....Salt Lake City

OFFICERS OF THE BOARD

A. W. IVINS.....President
FRANK B. STEPHENS.....Vice-President
JOHN L. COBURN.....Secretary-Treasurer

EXPERIMENT STATION STAFF

E. G. PETERSON, Ph. D., President of the College
WILLIAM PETERSON, B. S.,.....Director and Geologist
H. J. FREDERICK, D. V. M.,.....Veterinarian
F. L. WEST, Ph. D.,.....Physicist
J. E. GREAVES, Ph. D.,.....Chemist and Bacteriologist
W. E. CARROLL, Ph. D.,.....Animal Husbandman
BYRON ALDER, B. S.,.....Poultryman
GEORGE R. HILL, Jr., Ph. D.,.....Botanist
O. W. ISRAELSEN, M. S.,.....Irrigation and Drainage Engineer
D. S. JENNINGS, Ph. D.,.....Soil Surveys
*R. J. BECRAFT, B. S.,.....Range Management
GEORGE STEWART, M. S.,.....Field Crops
R. L. HILL, Ph. D.,.....Human Nutrition
E. B. BROSSARD, Ph. D.,.....Farm Management
I. M. HAWLEY, Ph. D.,.....Entomologist
W. L. WANLASS, Ph. D.,.....Marketing
GEORGE B. CAINE, M. A.,.....Dairying
C. T. HIRST, M. S.,.....Associate Chemist
WILLARD GARDNER, Ph. D.,.....Associate Physicist
B. L. RICHARDS, Ph. D.,.....Associate Botanist
EZRA G. CARTER, M. S.,.....Associate Bacteriologist
M. D. THOMAS, A. B., B. Sc.,.....Associate Agronomist
D. W. PITTMAN, M. S.,.....Assistant Agronomist
A. F. BRACKEN, B. S.,.....Assistant Agronomist
T. H. ABELL, M. S.,.....Assistant Horticulturist
GUSTAV WILSTER, M. S.,.....Assistant Dairyman
L. F. NUFFER, B. S.,.....Assistant Botanist
HERBERT J. PACK, B. S.,.....Assistant Entomologist
A. L. WILSON, B. S.,.....Superintendent Davis County Farm
J. R. BATEMAN, B. S.,.....Superintendent Panguitch Farm
PETER NELSON, B. S.,.....Farm Superintendent
BLANCHE CONDIT-PITTMAN, A. B.,.....Clerk and Librarian
DAVID A. BURGOYNE, B. S.,.....Secretary to the Director

IN CHARGE OF COOPERATIVE INVESTIGATIONS WITH THE U. S. DEPARTMENT OF AGRICULTURE

L. M. WINSOR, B. S.,.....Irrigation Engineer

*On leave.

THE IRRIGATION OF BARLEY

By

F. S. HARRIS and D. W. PITTMAN*

The proper use of irrigation water is one of the most important problems of every community and of every farmer in an irrigated district. The irrigation farmer has largely under his control one of the most important factors in determining the yield and quality of his crops and one over which all other farmers have little control at all. On the other hand, in an arid district there is generally less available irrigation water than is needed to give the optimum amount to all the land, or if one region receives an excess there is generally an accumulation of alkali in some lower region. Consequently, the proper distribution and use of irrigation water is of the highest importance to the community and demands first of all a knowledge of the effects of different irrigation treatments on various crops. It is the purpose of this bulletin to add its bit of information to this store.

WORK OF OTHERS

Much of the previous experimental work on the irrigation of small grains has been reviewed by the senior author in Utah Station Bulletin No. 146. Some of that pertaining directly to the irrigation of barley will be mentioned here.

In 1898 Mayer[1] reported some pot experiments showing that with soils maintained uniformly at different moisture contents, those having the lower moisture contents gave a higher proportion of grain to straw and earlier maturity. He found the optimum moisture content for barley to be less than for oats, wheat, or rye—that for barley being 62 per cent of the total water capacity of the soil.

From his pot experiments in Canada Reynolds[2] states that it required 18.52 inches of water to mature a crop of barley.

Nowell[3] in 1908 reported a field experiment on the irrigation of barley in Wyoming in which four irrigations totaling 19.56 acre-inches of irrigation water gave a higher yield than either more or less.

---

*The authors wish to acknowledge their indebtedness to Mr. Albert Allen for preparing these tables and figures for publication and to the Irrigation Committee of the Utah Experiment Station for consideration and advice on the manuscript.

[1]Mayer, A.—On of the Influence of Smaller and Larger Amounts of Water on the Development of Some Cultivated Plants. IN Jour. Landw., 46 (1892), No. 2, pp. 167-184. Abs. in E. S. R., Vol. X, p. 635.

[2]Reynolds, J. B.—Experiments on Evaporation and Transpiration. IN Ann. Rpt. Ontario Dept. Agr. (1905), pp. 41, 42.

[3]Nowell, H. T.—Irrigation of Barley. Wyo. Exp. Sta. Bul. 77 (1908).

In experiments with supplemental irrigation in connection with dry-farming at Cheyenne, Wyoming, Gordon[1] secured greatly increased yields of barley with a 6.6-inch irrigation.

Farrell[2], in duty-of-water experiments at Gooding, Idaho, found a higher yield of barley with 22.5 acre-inches of irrigation water than with a less quantity but found the greatest efficiency with about 12 inches.

Experiments reported by Beckett[3] at the Davis Farm in California (1909-12) show that the application of water to barley always gave a profit and that a late application gave better yields than an early one.

From a three years' field experiment ending in 1914 at Scottsbluff, Nebraska, Knorr[4] reports a 7-bushel increase in yield of barley from fall irrigation as compared to ordinary summer irrigation without a fall application.

Alchevski[5], experimenting with grain in wooden tanks in Egypt in 1914, found that the yield of barley increased with the irrigation water applied up to a depth of 70 cm. (27.5 inches) which was the maximum he used.

Oregon field experiments reported by Powers[6] in 1917 show the greatest yield of barley with the largest amount of irrigation water used, which was only 16.3 inches. He found the time of application and the soil fertility to be important factors in the efficiency of the use of water.

Welch[7] at the Gooding Substation in Idaho tested the effect of using two different sized irrigation streams. The smaller stream giving the larger application (a total of 11.2 inches) gave the largest yield. In studies of the duty of water covering three years he found 18 acre-inches sufficient for a crop of barley.

---

[1]Gordon, J. H.—Experiments in Supplemental Irrigation with Small Water Supplies at Cheyenne, Wyoming, in 1909. U. S. D. A. Off. Exp. Sta. Cir. 95 (1910), p. 11.

[2]Farrell, F. D.—Work of the Gooding Substation. IN Idaho Country Life, Vol. 4 (1911), No. 9, pp. 13-15, 19. Abs. in E. S. R. Vol. XXV, p. 635.

[3]Beckett, S. H.—Progress Report of Cooperative Experiments at California University Farm, Davis, California. U. S. D. A. Bul. 10 (1913), p. 21.

[4]Knorr, F.—Experiments with Crops under Fall Irrigation at the Scottsbluff Reclamation Project Experiment Farm. U. S. D. A. Bul. 133 (1914), p. 9.

[5]Alchevski,—Bul. Dir. Gen. Agr. Com. et Colon. Tunis, 18 (1914), No. 80, pp. 583-587. Abs. in E. S. R. Vol. XXXIII, p. 225.

[6]Powers, W. L.—The Economical Use of Irrigation Water. Ore. Exp. Sta. Bul. 140 (1917), p. 79.

[7]Welch, J. S.—Experiments with Small Grains under Irrigation. Idaho Exp. Sta. Bul. 93 (1917), p. 24.

Results somewhat contradictory to those of Knorr, already mentioned, were secured by Farrell and Aune[1] at Belle Fourche, South Dakota. The latter found fall irrigation of no value to barley on their heavy compact soil. It is not improbable that the variance in the results was due to soil differences.

Beckett[2] of California found as a result of eight years' study that under their conditions the application of irrigation water in seasons of deficient rainfall increased the yield of barley up to the point where the total irrigation plus precipitation was equal to 22 acre-inches.

Harlan and Anthony[3], working at Aberdeen, Idaho, found that late irrigations, even after the plant had changed color, increased the size and weight of barley kernels, but they do not report the effect on the yield as a whole.

Two investigators working in distinctly humid climates have found irrigation beneficial. King[4] at Wisconsin found in one experiment that while irrigation did not appreciably increase the yield of barley it gave a second crop of mixed barley and clover hay which was not secured on the unirrigated plats. Davidson[5] at Iowa secured an increase of 12.5 bushels of barley per acre and an increased weight per bushel with two 2-inch irrigations.

PREVIOUS WORK AT THE UTAH STATION

Since its establishment the Utah Experiment Station has attached much importance to the study of irrigation. Barley, however, has not been so thoroughly studied as some of the other crops because it occupies a relatively small acreage in the state.

Widtsoe[6] shows that with an increased irrigation up to 39.5 inches there is an increase in the total dry-matter production on barley plats, but Widtsoe and Merrill[7] state that the yield

[1]Farrell, F .D., and Aune, B.—Effect of Fall Irrigation on Crop Yields at Belle Fourche, South Dakota. U. S. D. A. Bul. 546 (1917), p. 13.

[2]Beckett, S. H.—Irrigation of Barley. IN Calif. Exp. Sta. Ann. Rpt. (1919), p. 47.

[3]Harlan, H. V., and Anthony, S.—Effect of Time of Irrigation on Kernel Development of Barley. IN Jour. Agr. Rsch., Vol. 21 (1921), No. 1, pp. 29-45.

[4]King, F. H.—The Importance of the Right Amount and the Right Distribution of Water in Crop Production. IN Wis. Exp. Sta. Ann. Rpt. (1897), pp. 216-218.

[5]Davidson, J. B.—Irrigation Experiments. IN Iowa State Col. Agr. Rpt. (1907-08), pp. 188-190.

[6]Widtsoe, J. A.—The Production of Dry Matter with Different Quantities of Irrigation Water. Utah Exp. Sta. Bul. 116 (1912), pp. 1-64.

[7]Widtsoe, J. A., and Merrill, L. A.—The Yields of Crops with Different Quantities of Irrigation Water. Utah Exp. Sta. Bul. 117 (1912), pp. 66-119.

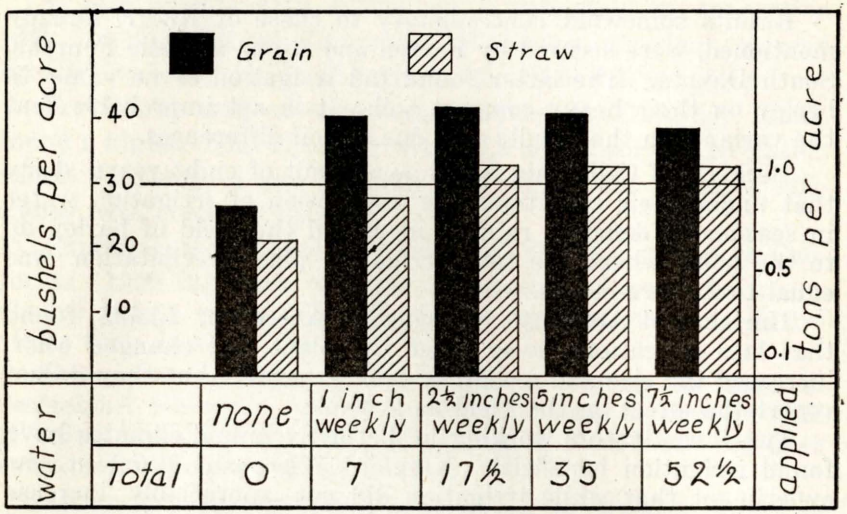


Fig. 1.—Yield of barley, grain, and straw on plats receiving different quantities of irrigation water weekly

of grain decreased in these experiments when more than 7.5 acre-inches were applied.

Widtsoe and Stewart[1], analyzing these crops, found that there is an increase in the relative amount of ash and a decrease in the protein with increased irrigation. The proportion of crude fiber in the straw was also increased by increased irrigation, but this effect was not noticeable in the grain.

EXPERIMENTAL RESULTS

DESCRIPTION OF THE EXPERIMENT

The experimental work reported in this bulletin was conducted on the Greenville Experimental Farm two miles north of Logan, Utah. The soil of this farm has been described in detail in previous publications of this Station (Utah Sta. Bul. 115). It is a uniform loam to considerable depth and carries about 22 per cent of moisture as a maximum under field conditions. The plats were 29 feet wide by 57 feet long. This gives an area of 1/26.352 of an acre in each plat, exclusive of a 7½-foot space between each. Six-rowed barley was drilled in at the rate of two bushels per acre on all the plats.

The water was measured by means of a Cippoletti weir and taken to the land in wooden flumes where it was added to the

[1]Widtsoe, J. A., and Stewart, Robt.—The Chemical Composition of Crops as Affected by Different Quantities of Irrigation Water. Utah Exp. Sta. Bul. 120 (1912), pp. 201-204.

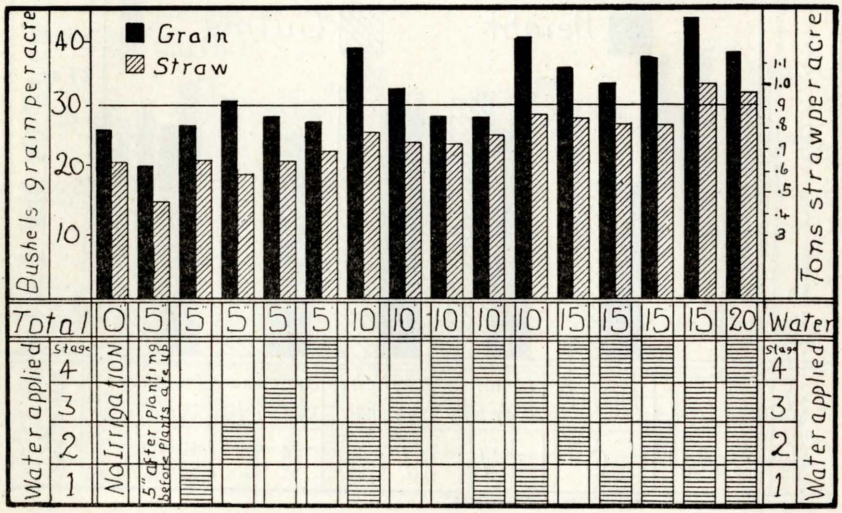


Fig. 2.—Yield of barley, grain, and straw on plats receiving various quantities of irrigation water at different stages

grain by the flooding method. All of the water was retained on the plats by dikes around the edges. To a number of plats water was added each week during the growing season, but the time of applying the water to most of the plats depended on the stage of development of the plants.

The crop growth was divided into four stages as follows: (1) the stage when five leaves had developed and the plants were six or eight inches high; (2) the early boot stage when the plants were just swelling preparatory to heading; (3) the bloom; and (4) when the plants were in the dough stage.

An irrigation five inches deep was used as a standard at these stages. An application of this amount was given to the different plats so as to include the following combinations: each stage, each two stages, each three stages, and all four stages. It is possible, therefore, from the results obtained to determine which stages are best when either one, two, or three irrigations are used.

In the weekly irrigations, one plat received 1 inch, another 2.5 inches, another 5 inches, and another 7.5 inches of water each week during the season, beginning when the grain was five or six inches high and continuing until it began to turn yellow.

The experiment was begun in 1919 and carried through 1920 and 1921. As the plats had previously been in oats for three

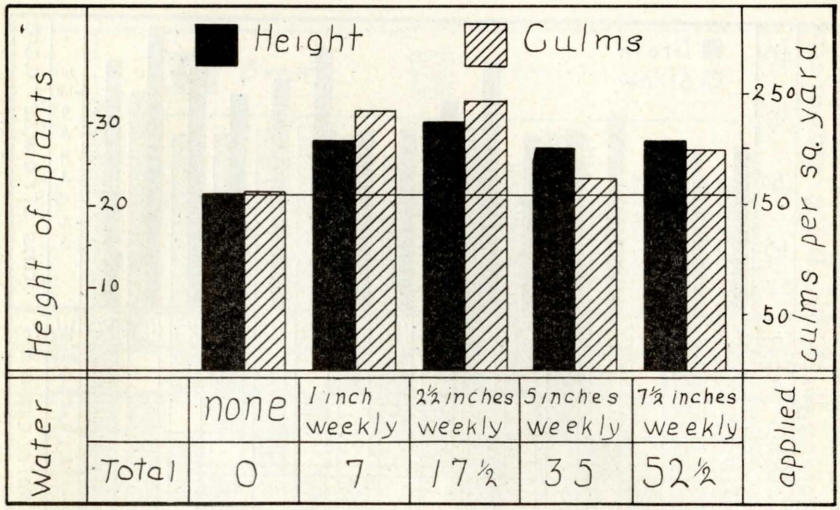


Fig. 3.—Height of barley plants and number of culms per square yard on plats receiving different quantities of irrigation water weekly

years and wheat for four years they were getting rather "grain sick" so that the yields were not as good as they should have been. However, as the different plats had previously grown the same grains, the results are comparable.

PRECIPITATION

The precipitation during the years of the experiment is shown in Table I. These figures are given for the fall and winter preceding the growing season and for the growing season rather than for the calendar year in order to better observe the effect of the rainfall on the crop. The figures for October to March, inclusive, 1918-19, and November to March, inclusive, 1919-20, as well as the 30-year averages, are taken from the Logan rain gauge. The other figures were taken on the experimental farm. In considering these results it is important to remember that the snowfall in this valley is always sufficient so that the soil at planting time in the spring contains about as much water as it will hold, making irrigation to induce germination unnecessary either before or after planting. On the other hand, the summer precipitation is seldom sufficient to be of any real value to the crop.

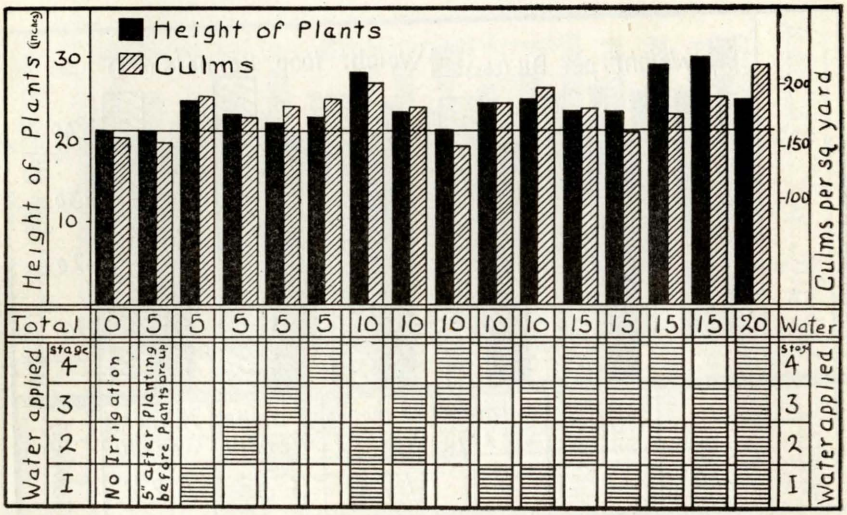


Fig. 4.—Height of barley plants and number of culms per square yard on plats receiving various quantities of irrigation water at different stages

YIELD OF GRAIN AND STRAW

The average yield of the crop under the different irrigation treatments is shown graphically in Figures 1 and 2. The actual figures by years and the average are given in the appendix. Figure 1 shows the average yield of grain and of straw on the plats receiving 1 inch, 2.5 inches, 5 inches, and 7.5 inches of irrigaton water every week for seven weeks in comparison with an unirrigated plat. The irrigations were started when

TABLE I.—PRECIPITATION BY MONTHS DURING THE EXPERIMENT, 1919-21, INCLUSIVE.

Month	1918-19	1919-20	1920-21	Average 3 Years	Average 1891-1921
September	1.12	2.32	1.77	1.74	1.21
October	2.56	4.54	4.38	3.83	1.66
November	.94	.73	1.74	1.14	1.21
December	.35	1.49	1.66	1.17	1.29
January	.02	.26	1.53	.60	1.62
February	1.88	1.24	1.55	1.56	1.52
March	.74	2.73	2.61	2.03	1.98
April	1.50	3.20	3.87	2.86	1.79
May	1.04	.94	2.04	1.34	2.17
June	.00	.34	.22	.19	.83
July	.06	.25	.15	.15	.59
August	.15	1.34	.40	.63	.64
Total	10.36	19.38	21.92	17.22	16.50

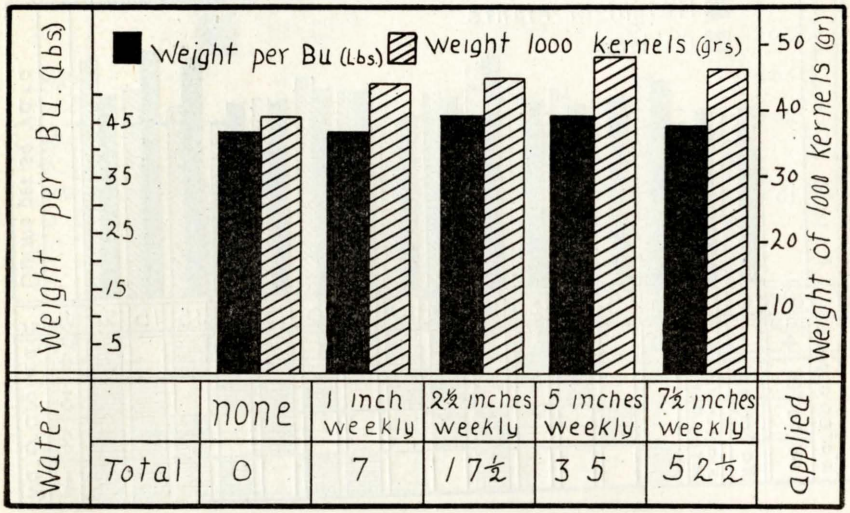


Fig. 5.—Weight of grain per measured bushel and weight of kernels of barley on plats receiving different quantities of irrigation water weekly

the plants had five leaves (first stage) and discontinued when the grain was in the dough (fourth stage). The water was measured in acre-inches, an acre-inch being enough water to cover the ground one inch deep if it were perfectly level and none soaked in. The height of the black column represents the yield of the grain and the light column the straw. It is readily seen that the plat receiving 2.5 inches each week, or a total of 17.5 inches in the season, gave a higher yield of grain than those receiving either more or less water. More than 2.5 inches of water per week did not seem to affect the yield of straw.

Figure 2 shows the yield of grain and straw for the plats irrigated at the different stages. The plat which received 5 inches of water at the first three stages (5-leaf, early boot, and full-bloom) gave the highest yield of grain on any plat in the experiment, it being the only plat to outyield the one with 2.5 inches of water each week. The plat which was watered at all four stages (20 inches in all) gave less than either of these.

Of the plats receiving only 5 inches of water, the one irrigated at the second stage (boot) did best and the third stage next best. Of those receiving 10 inches the first and third, and first and second stages were decidedly the best. Of those receiving 15 inches, the one in which the second stage was omitted did the worst and the one with the last stage omitted did the best.

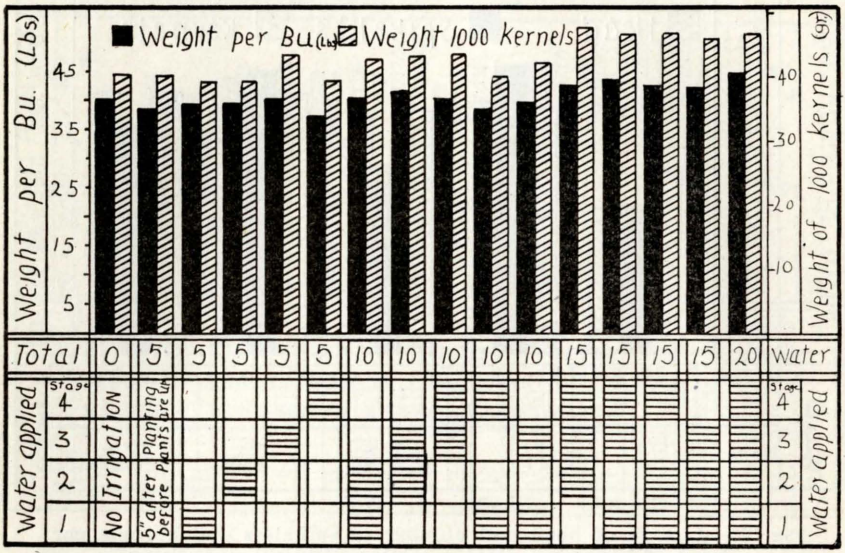


Fig. 6.—Weight of grain per measured bushel and weight of kernels of barley on plats receiving various quantities of irrigation water at different stages

All this seems to show the importance of having most of the irrigation water of the season applied by the time the barley has reached the boot stage. The early (5-leaf) irrigation seems to be important when followed by subsequent irrigations but is not so good where it is the only irrigation given. The last stage irrigation, when the grain was in the dough, was of little value to the grain in any case. In similar experiments with wheat[1] and oats[2] the first-stage irrigation appeared to be the best.

On one of the plats a 5-inch irrigation was given after planting the seed and before it came up, after the manner of "watering-up" grain practised in some districts. As no subsequent cultivation was given the ground crusted, the stand was poor, and the yield was invariably less than that of the plat with no irrigation at all. Even though on one year it was impossible to get the water until the grain was up and had three leaves, the yield was much reduced by this treatment.

The yield of straw agrees closely with that of the grain except that it was not reduced by excessive irrigation, and in the case of only one irrigation the second stage which gave the

[1]Harris, F. S.—The Irrigation of Wheat. Utah Exp. Sta. Bul. 146 (1916), p. 32.

[2]Harris, F. S. and Pittman, D. W.—The Irrigation of Oats. Utah Exp. Sta. Bul. 167 (1919), p. 20.

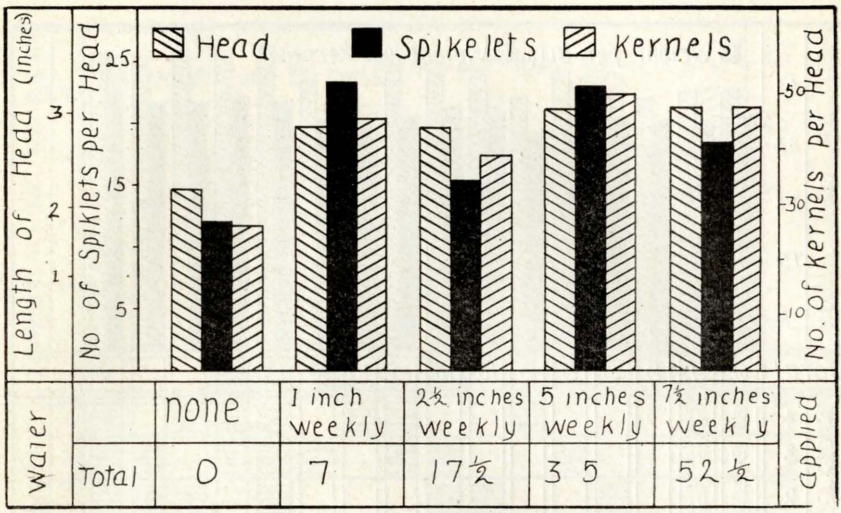


Fig. 7.—Length of head and number of spikelets and kernels per head of barley on plats receiving different quantities of irrigation water weekly

most grain gave the least straw. The value of the straw is not generally sufficient to be a determining factor in irrigation practice.

OTHER EFFECTS OF IRRIGATION

In order to get figures that might be of value either by themselves or of use in interpreting these figures, data were taken on the height of the plants, the thickness of stand or number of culms per square yard, the weight of the grain per bushel, the length of head, weight of kernels, number of spikelets per head, and number of kernels per head. It was planned also to get data on the date of maturity of the grain, but it ripened so unevenly on all of the plats that no definite data could be given. In general, however, the weekly watered plats and those receiving water at the later stages were a few days later in ripening than the others.

EFFECTS ON THE PLANTS

The effects of the different irrigation treatments on the height of the barley plants and on the density of stand are shown in Figures 3 and 4. These results agree in general but not entirely with the yield. Of the plats watered weekly, that receiving 2.5 inches per week has the tallest grain and the thickest stand (most tillering). Of the plats watered at dif-

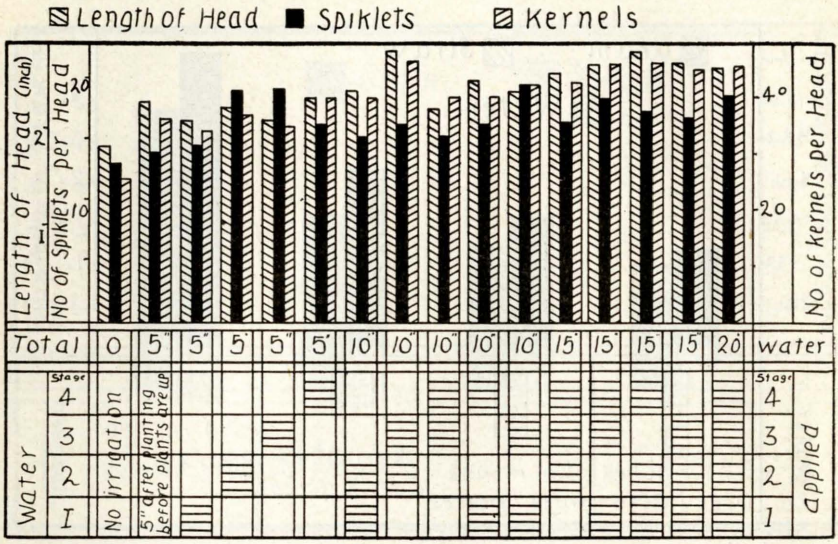


Fig. 8.—Length of head and number of spikelets and kernels per head of barley on plats receiving various quantities of irrigation water at different stages

ferent stages the early irrigations seem to be more effective in producing tall grain and a dense stand. Where only one irrigation was given, the first was best; where two were given, the first two were best; and where three were given, the first three were best—all indicating that the moisture available at the early stages of growth has much to do with the tillering of the plants and their subsequent vegetative growth.

Figures 5 to 8, inclusive, show the effect of the different irrigation treatments on the grain itself and the character of the head. In Figures 5 and 6 is shown the effect of the irrigations on the weight of the grain in pounds per bushel and the weights of the individual kernels. It shows in general that the plats receiving 15 inches, or more, of irrigation water had heavier grain than the others. Only the plats receiving the most water per week seemed to have an excess in this respect. The greatest weight per bushel was on the plat receiving four 5-inch irrigations. The lowest were from the plat watered up and that receiving only the last stage of irrigation. The late irrigation water was effective in making heavy grain only when there had been vigorous growth during the early stages. The heaviest individual kernels were in general produced on these same plats. The average length of head and number of spikelets and kernels per head, as determined by measuring and

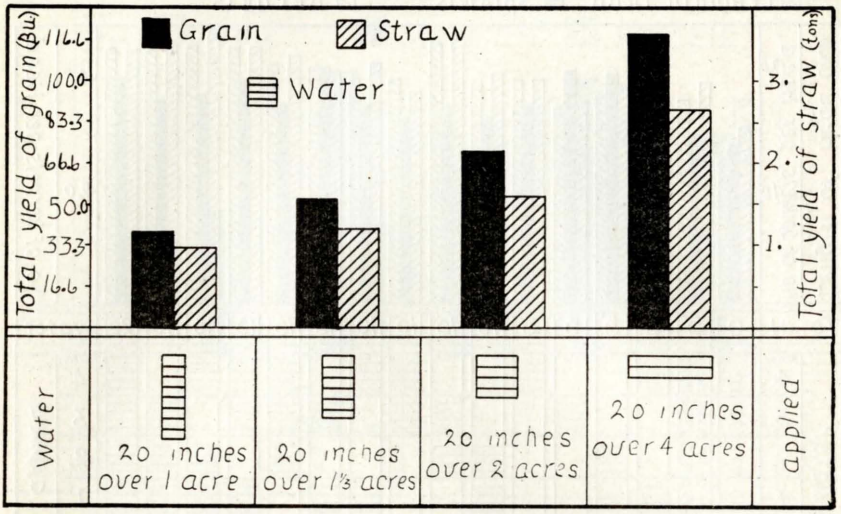


Fig. 9.—Amount of barley produced by 20 acre-inches of irrigation water when applied to one acre, one and one-third acres, two acres, and four acres of land, respectively

counting 100 heads selected at random from the plats, are shown in Figures 7 and 8. They show no definite correlation with either the yield or the irrigation treatment except that the length of head follows in general the yield of straw.

In interpreting these results there are certain economic phases of the problem that should not be overlooked. It must be remembered that under the conditions of this experiment the natural precipitation produced a fairly good yield of grain, the yield on the dry plat being about 60 per cent of that of the plat receiving the most favorable irrigation treatment. Under these conditions in a district where there was insufficient water for all of the land a greater total production of grain could be secured by applying the water in small quantities to a larger area. Figure 9 shows the amount of barley produced with 20 acre-inches of irrigation water applied to one, one and a third, two, and four acres of land, respectively. More grain is produced for a given quantity of water where it is spread over a large area of land.

Figure 10 shows the yield of barley for each acre-inch of irrigation water when applied at 5, 10, 15, and 20 inches total irrigation. This presentation might be of value in districts of similar climatic conditions where water is relatively much more valuable than land. The returns from each inch of water continue to decrease as the quantity applied to the acre increases.

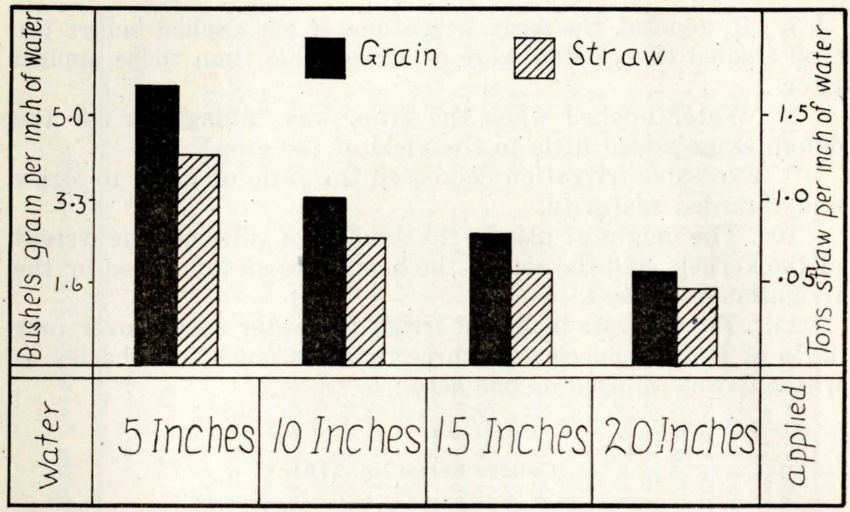


Fig. 10.—Yield of barley for each inch of irrigation water on plats receiving dfferent quantites of irrigation water

It is of further economic interest to note that barley as well as the other grains use early water to best advantage, whereas some other crops such as alfalfa, sugar-beets, and potatoes use water to best advantage during later months of summer when the supply in the canals is likely to be less.

SUMMARY

1. In this bulletin some results of previous experiments on irrigation of barley are summarized and three years of experimental results on the Greenville Farm are reported.

2. Under the conditions of the experiment with an average annual precipitation of 16.5 inches and a deep soil with good water-holding capacity, irrigation water must be considered as supplemental only.

3. The highest yield was produced with three irrigations of 5 acre-inches each applied at the 5-leaf, boot, and bloom periods of growth.

4. Of the plats irrigated weekly during the season, the one receiving 2.5 inches each week, a total of 17.5 inches, yielded better than those with larger or smaller weekly applications.

5. The yield was greater for 15 inches of irrigation water than for a larger quantity.

6. Water applied after the grain was planted and before it was up decreased the yield as compared to the unirrigated plat.

7. In general, the early irrigations if not applied before the crop shaded the ground were of more value than those applied later.

8. Water applied when the grain was "filling" or in the dough stage added little to the yield of the crop.

9. Excessive irrigation decreased the ratio of grain to straw and retarded maturity.

10. The height of plants, the amount of tillering, the weight of the kernels, and the size of the head were all influenced by the irrigation treatment.

11. Twenty acre-inches of irrigation water spread over four acres of land produced over three times as much total barley as where it was all used on one acre.

(College Series No. 175)

APPENDIX

Detailed data regarding crop on each plat for each of the three years of the experiment

No.		Yield of Grain (Bu. per Acre)				Yield Straw (Tons Per Acre)				Av. Height of Plants (Inches)			
		1919	1920	1921	Av.	1919	1920	1921	Av.	1919	1920	1921	Av.
1	1 inch weekly	45.0	45.0	30.7	40.2	0.751	1.093	0.804	0.883	27	30	26	28
2	2½ inches weekly	43.3	48.3	34.0	41.8	1.067	1.251	0.935	1.084	30	30	31	30
3	5 inches weekly	48.8	37.8	35.7	40.6	1.159	1.001	0.883	1.014	33	26	23	27
4	7½ inches weekly	50.5	34.0	31.8	38.7	1.186	1.015	0.812	1.007	33	27	24	28
5	None	19.7	28.0	31.3	26.3	0.527	0.804	0.593	0.641	23	20	21	21
6	5 inches after planting, before plants are up	12.6	22.5	27.5	20.8	0.316	0.567	0.501	0.461	23	21	19	21
7	5 inches, 1st stage (5 leaves)	25.2	24.7	30.7	20.8	0.653	0.712	0.593	0.655	30	23	21	25
8	5 inches, 2nd stage, (early boot)	29.6	30.1	32.4	30.7	0.553	0.580	0.619	0.584	28	23	19	23
9	5 inches, 3rd stage (bloom)	26.9	28.0	30.7	28.5	0.606	0.659	0.659	0.641	25	21	20	22
10	5 inches, 4th stage, (dough)	21.4	30.0	30.2	27.2	0.672	0.725	0.685	0.694	25	20	21	22
11	20 inches, 5 inches each at the 1-2-3-4 stages	41.7	37.3	35.7	38.2	0.988	1.067	0.909	0.988	29	26	20	25
12	15 inches, 5 inches each at the -2-3-4 stages	40.0	34.5	33.5	36.0	0.909	0.830	0.856	0.865	26	24	19	23
13	15 inches, 5 inches each at the 1-3-4 stages	36.2	32.3	32.9	33.8	0.856	0.843	0.777	0.825	27	21	22	23
14	15 inches, 5 inches each at the 1-2-4 stages	37.8	40.0	35.7	37.8	0.909	0.817	0.751	0.826	28	29	23	27
15	15 inches, 5 inches each at the 1-2-3-stages	43.3	48.3	39.0	43.5	0.962	1.067	0.975	1.001	32	30	22	28
16	10 inches, 5 inches each at the 1-2- - stages	36.2	42.8	38.4	39.1	0.712	0.870	0.777	0.786	28	30	24	27
17	10 inches, 5 inches each at the -2-3- stages	31.2	36.2	30.7	32.7	0.698	0.817	0.659	0.725	27	22	20	23
18	10 inches, 5 inches each at the - -3-4 stages	29.1	28.5	27.5	28.3	0.659	0.804	0.685	0.716	25	21	18	21
19	10 inches, 5 inches each at the 1- -4 stages	26.3	29.1	29.6	28.3	0.804	0.777	0.725	0.769	28	25	20	24
20	10 inches, 5 inches each at the 1-3- stages	40.6	42.8	39.0	40.8	0.725	1.001	0.896	0.874	29	24	23	25
	Average	34.3	34.8	32.8	34.0	0.785	0.865	0.755	0.802	28	25	22	25

APPENDIX

(Continued)

Detailed data regarding crop on each plat for each of the three years of the experiment

No.		Culms Per Sq. Yd				Wt. Per 1000 Kernels				Length of Head (inches)		
		1919	1920	1921	Av.	1919	1920	1921	Av.	1920	1921	Av.
1	1 inch weekly	246	210	259	238	43	44	47	44	2.76	2.43	2.59
2	2½ inches weekly	231	220	289	247	46	47	44	45	2.53	2.56	2.55
3	5 inches weekly	172	165	191	176	47	48	49	48	2.60	2.92	2.76
4	7½ inches weekly	220	196	203	206	46	45	48	46	2.59	2.97	2.78
5	None	187	140	155	161	33	45	43	40	1.48	2.18	1.83
6	5 inches after planting, before plants are up	87	148	236	157	38	42	42	40	1.69	2.91	2.30
7	5 inches, 1st stage (5 leaves)	209	176	217	201	33	41	44	39	2.05	2.25	2.15
8	5 inches, 2nd stage, (early boot)	116	139	210	188	31	43	44	39	1.89	2.58	2.24
9	5 inches, 3rd stage (bloom)	199	142	248	196	40	47	44	43	2.23	2.14	2.19
10	5 inches, 4th stage, (dough)	232	124	247	201	32	41	44	39	2.32	2.42	2.37
11	20 inches, 5 inches each at the 1-2-3-4 stages	194	184	266	215	46	47	47	46	2.73	2.63	2.68
12	15 inches, 5 inches each at the -2-3-4 stages	191	157	234	194	46	48	47	47	2.73	2.54	2.64
13	15 inches, 5 inches each at the 1-3-4 stages	139	155	209	168	44	47	49	46	2.63	2.84	2.74
14	15 inches, 5 inches each at the 1-2-4 stages	181	175	188	181	43	48	47	46	2.60	2.97	2.79
15	15 inches, 5 inches each at the 1-2-3-stages	205	200	205	203	45	44	46	45	2.43	3.01	2.72
16	10 inches, 5 inches each at the 1-2- - stages	191	174	261	209	42	41	45	42	2.34	2.57	2.46
17	10 inches, 5 inches each at the -2-3- stages	200	142	246	196	39	47	43	43	2.60	3.06	2.83
18	10 inches, 5 inches each at the - -3-4 stages	143	120	204	156	41	47	43	43	2.34	2.12	2.23
19	10 inches, 5 inches each at the 1- -4 stages	180	158	232	190	39	42	40	40	2.30	2.75	2.53
20	10 inches, 5 inches each at the 1-3- stages	197	128	292	206	40	43	44	42	2.40	——	2.40
	Average	186	163	229	194	41	45	45	41	2.36	4.35	2.49

APPENDIX

(Concluded)

Detailed data regarding crop on each plat for each of the three years of the experiment.

No.		No. Spikelets Per Head			No. Kernels Per Head			Wt. Per Bu. (lbs.)			
		1920	1921	Av.	1920	1921	Av.	1919	1920	1921	Av.
1	1 inch weekly	31.41	16.51	23.96	53.57	38.20	45.89	44	44	40	43
2	2½ inches weekly	15.40	16.51	15.96	42.39	36.22	39.81	46	47	45	46
3	5 inches weekly	28.01	18.23	23.12	49.21	51.14	50.18	46	50	42	46
4	7½ inches weekly	17.94	18.78	18.36	47.16	47.19	47.18	47	46	43	45
5	None	10.55	13.93	12.24	23.82	29.39	26.61	42	46	40	43
6	5 inches after planting, before plants are up	9.23	18.65	13.90	26.75	47.15	36.95	40	42	40	41
7	5 inches, 1st stage (5 leaves)	13.94	15.01	14.48	36.92	33.07	34.99	40	44	41	42
8	5 inches, 2nd stage, (early boot)	21.30	16.86	19.08	34.11	40.04	37.08	40	45	42	42
9	5 inches, 3rd stage (bloom)	24.19	13.81	19.00	40.57	31.09	35.83	42	45	42	43
10	5 inches, 4th stage, (dough)	15.95	16.28	16.12	42.52	39.78	41.15	37	43	41	40
11	20 inches, 5 inches each at the 1-2-3-4 stages	19.91	17.58	18.75	50.14	45.16	47.65	46	46	48	47
12	15 inches, 5 inches each at the -2-3-4 stages	16.25	16.41	16.33	49.11	39.76	44.44	45	47	44	45
13	15 inches, 5 inches each at the 1-3-4 stages	18.26	18.25	18.26	48.38	45.91	47.15	45	46	47	46
14	15 inches, 5 inches each at the 1-2-4 stages	17.47	17.64	17.56	47.92	46.18	47.05	44	47	46	46
15	15 inches, 5 inches each at the 1-2-3-stages	14.49	19.09	16.79	42.62	50.15	46.39	45	44	45	45
16	10 inches, 5 inches each at the 1-2- - stages	13.55	17.13	15.34	40.89	41.02	40.96	44	42	42	43
17	10 inches, 5 inches each at the -2-3- stages	17.20	15.60	16.40	46.87	49.24	48.06	42	47	44	44
18	10 inches, 5 inches each at the - -3-4 stages	13.93	17.05	15.49	40.03	42.53	41.28	43	45	40	43
19	10 inches, 5 inches each at the 1- -4 stages	13.81	18.51	16.16	40.25	46.37	41.39	41	43	40	41
20	10 inches, 5 inches each at the 1-3- stages	17.84	21.40	19.62	43.76	42.05	42.91	42	43	42	42
	Average	17.53	17.16	17.34	42.35	42.08	42.14	43	45	42	44